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ABSTRACT

The first section of this report examines, from a developmental perspective, the major theoretical positions dominating the literature on adult cognition. Two criteria are considered. First, how compatible are the theories with the notion that thinking systems develop within specific environments? Second, what are the implicit or explicit assumptions concerning the developmental processes of growth? The second section examines the general class of levels-of-processing (LOP) models, which, unlike other theories of adult cognition, have been widely adopted by developmentalists. The essential compatibility of LOP models and developmental interests follows from a shared concern with three main issues: the importance of involuntary memory, the activity of the subject and the goal of that activity, and "headfitting" (the compatibility between what is known and what can be known). Developmental data are often particularly apt demonstrations of the main tenets of the LOP frameworks, and LOP models provide a language and a viewpoint through which the issues of interest to developmentalists can be reinterpreted. (AA)

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CENTER FOR THE STUDY OF READING

Technical Report No. 51

Theories of Memory and the Problems of Development: Activity, Growth, and Knowledge[1]

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I. Introduction

This chapter consists of two parts. In the first section, I examine briefly, from a developmental perspective, the major theoretical positions dominating the literature on adult cognition. Two criteria are considered: first, how compatible are the theories with the notion that thinking systems develop within living environments? Second, what are the implicit or explicit assumptions of the theories concerning the quintessential developmental problem of growth.

In the second section I consider the general class of levels of processing models. These frameworks, unlike other theories of adult cognition, have been widely adopted by developmentalists. I argue that developmental theories are particularly compatible with such models because they are themselves variants of levels of processing approaches. Both emphasize three major issues: the importance of involuntary memory, the activity of the subject and the goal of that activity, and headfitting, i.e., the compatibility between what is known and what can be known. To illustrate, I compare current levels of processing models and similar developmental theories, notably European structuralism, as represented by Piaget, and Soviet dialecticism, as represented by Leont'ev, Vygotsky and Zinchenko. The European tradition and the emergence of level of processing frameworks converged to assert a powerful influence on developmental studies of cognition. Throughout the chapter I have attempted to demonstrate where developmental data are particularly relevant for an issue of concern for adult theories and where adult models can guide the theory construction of developmentalists. To date, however, the dominant approach to human cognition has been teleological and there is an implicit acceptance that human thought processes reach a steady state, i.e., become static and immutable at maturity. I argue here that a consideration of ontogenetic factors would increase our understanding not only of the child but of the adult thinker.

II. Theories of Cognition and the Problem of Growth

The dialogue between developmental psychology and adult cognition has been less than a vital force in the evolution of either discipline; why this lack of communication?

At the trivial level it is true that the adherents often fail to follow each other's literatures, an oversight which is inevitable given the information overload resulting from the proliferation of research outlets. I have been reduced to treating the task of following current controversy in adult cognition as a semantic shadowing task; I only divert my full attention to the relatively unattended channel when a topic of particular personal salience is raised.

In general, developmental psychologists have shown a lamentable insensitivity to the need for theory guided research, perhaps due to the origins of the discipline, rooted as they are in clinical and educational practice. As such it is not uncommon to encounter developmental cognitive psychologists who are not only unaware of major trends in adult cognition, but are also oblivious to the need for such awareness. By the same token, cognitive psychologists often fail to consider pertinent developmental data even when such data could provide the optimal test for a question of interest. Cross-fertilization among the disciplines could be of help to both.

At a more fundamental level, the crucial issues for a developmentalist, i.e., change and growth, have not in the past been major concerns of adult models. In fact, adult models share major problems which are most apparent when the topic of cognitive growth is considered. It is precisely because of these characteristic weaknesses that developmental psychologists seeking theories have often looked elsewhere for guidance. In the next section I will illustrate this point with a cursory examination of the main trends in adult cognition. The concentration is on how the models speak to developmental concerns and how developmental data can be used to investigate some crucial issues for the models.

A. Information processing models: The computer metaphor.

Craik and Lockhart's (1972) original paper was primarily motivated by a reaction to the then dominant metaphor of adult cognition, the computer. I do not wish to reiterate their well-known criticisms here; instead I would like to add a further complaint arising from a developmental perspective. Computer metaphor models concentrate on the flow of

information in and between the major architectural structures of the system (STM, LTM, etc.). The primary issues are when, where, and how, rather than what information is processed. The principal structures of the system are fixed; they do not grow, neither do they function in dynamic interaction with a meaningful environment. Shaw and Bransford (1977) characterized the systems as "mechanistic," "purposeless," and "passive." A system that cannot grow, or show adaptive modification to a changing environment is a strange metaphor for human thought processes which are constantly changing over a life span of the individual and the socio-cultural evolution of the race (Kvale, 1975; Riegel, 1975). This is the major criticism of such models raised by ecological psychologists, for example, Shaw and Bransford who believe that a

> man-machine analogy becomes a hindrance rather than an aid to psychological theory when it derails our thinking about how living creatures gather and act upon knowledge in dynamic natural contexts. Such questions can in no way be reduced to questions of how information is represented, stored, or retrieved from storage by static devices in artificially controlled experiments. (Shaw & Bransford, 1977, pp. 4-5)

Notwithstanding these obvious limitations for a field devoted to understanding cognitive growth, theory-oriented developmental psychologists did adopt the prevailing metaphor, with some success, but also with many attendant problems that can serve to illustrate some limitations to the original model.

First the modal model of this type makes a sharp distinction between structure and process. This distinction has not gone unchallenged even within the domain of adult cognition (Winograd, 1975). As Newell (1972) has pointed out, what we regard as structure and what we regard as process is very much a function of the theoretical viewpoint we adopt. But this is even more troublesome for developmentalists for what we regard as structural must undergo change, if by structure we mean some limitation imposed by the impoverished state of the child's knowledge base (Brown, 1975; Chi, 1978).

A more specific type of structure limitation has been suggested by the computer models; it is more akin to the notion of channel capacity. If children do poorly on a rote recall task, one might ask whether this is because of some capacity limitation,

defined in terms of presence or absence of a major system, amount of space with one of the systems, or rate of decay. The notion that immature learners do suffer from some form of limited memory capacity is a dominant one (Chi, 1976), and it is only recently that a series of ingenious developmental studies (Chi, 1976, and Huttenlocher & Burke, 1976) have come to grips with the difficulties in distinguishing between the "capacity" limitations of the immature that are structural or procedural. In summary of this work, there appears to be no compelling data to suggest that capacity differences, defined by presence or absence of an architectural system (e.g., STM), amount of space in one of the architectural units (e.g., the number of slots in STM), or in terms of durability of information in these systems, differentiates the child from the adult thinker (Belmont, 1972; Belmont & Butterfield, 1969; Brown, 1974; Chi, 1976; Wickelgren, 1975). What does hamper the inexperienced is the paucity of strategic processes available to the system and the debilitating effect of an impoverished knowledge base (Brown, 1978a). The studies of Chi concerned with STM limitations and iconic memory in children illustrate the complexity of separating out process and structure, an illustration that is no less informative to the student of adult cognition.

Chi's (1976, 1978) theory is a good example of an information-processing developmental model which emphasizes the problems of an impoverished knowledge base. Long-term memory is seen as the repository of rules, strategies, and operations which can be used to make more efficient use of a limited capacity system; young children have not yet acquired these routines. In addition, Chi believes that the child's knowledge base is deficient in at least three ways: (a) the amount of information it contains, (b) the organization and internal coherence of that informaiton, and (c) the number of available routes by which it can be reached. These differences impose several limitations on the child's information-processing abilities, even in such simple situations as reading information from the icon or maintaining information in STM (Chi, 1975, 1976). Such basic cognitive processes as ease of retrievability, and speed of encoding, naming, and recognition are all influenced by restrictions imposed by an impoverished

knowledge base.

Although models such as Chi's provide some insight into what might develop within an information-processing framework, there are still some interesting difficulties when one tries to account for qualitative rather than quantitative growth. How does the system become rich, rather than impoverished, if by that we mean more than a mere accumulation of facts? How does the organization and internal cohesion of information change qualitatively with age? What is meant by the number of routes by which information is reached? Others have noted the problems with basic memory metaphors (Bransford & Franks, 1976; Neisser, 1967) with their emphasis on searching in discrete locations. If we really believe in an accumulation of facts, which become increasingly accessible by means of well-trodden routes, we must face fundamental problems when it comes to dealing with questions such as, how such a system can recognize novelty (Höffding, 1891; Neisser, 1967) and why the expert does not take longer to "access" his known facts than the novice (Bransford, Nitsch & Franks, 1977).

B. The episodic-semantic distinction.

One of the most influential distinctions to be made in the area of memory in recent years is that between semantic and episodic memory (Tulving, 1972). But the terms have come to mean different things to different people, and it is not at all clear that they produce either an exhaustive or exclusive classification. The confusion that has followed the idiosyncratic and varying usage of the terms has been dealt with elsewhere (Nelson & Brown, 1978). Here I will consider, briefly, the distinction in connection with how thinking systems grow.

In view of the controversy concerning terminology I will state explicitly my use of the terms. The term episodic is used to refer to a form of memory input leading both to remembered autobiographical events (Tulving, 1972), e.g., what happened on one's fifth birthday, and to the formation of generalized event structures, or scripts (Nelson, 1977; Schank, 1975), e.g., what you expect to happen in a restaurant, at a store, etc. Both Schank (1975) and Nelson (1977) conceive of these generalized event structures as

important components of an underlying conceptual memory, and as the most important component for the young child. The term semantic memory is reserved for the storing of information about words and concepts represented in the language, i.e., the strictly linguistic (lexical or semantic).

There has been a tendency in current developmental research to classify all of the child's real-world knowledge as semantic knowledge (Brown, 1975; see also Naus & Halasz, this volume) thereby avoiding the central question of how semantic structures develop from episodic experience. For example, there is an increasing body of literature concerned with the very young child's memory for non-linguistic information, such as spatial layouts (Siegel & White, 1975), spatial locations (Acredolo, Pick & Olsen, 1975; Harris,1973) and actions (Foellinger & Trabasso, 1977). But, these types of memories are neither "semantic" nor "episodic" as these terms have previously been defined. Clearly one of the major developmental questions, especially in the preschool period, is how such nonverbal memory relates to verbal memory, as well as vice versa. Labelling both types of representation semantic obscures rather than illuminates the problem.

The crucial developmental question has been raised and dropped by most theorists concerned with some variant of the episodic-semantic distinction. For example, Tulving (1972) stated that:

> relatively little is known about the role that the perceptual system and episodic memory play in the storage of information into semantic memory. Problems of acquisition of semantic information, and problems of modification of existing semantic structures, have not yet been studied by students of semantic memory. . . (Tulving, 1972, p. 393).

This statement emphasizes the uncertain relation between semantic and episodic memory and the role of experience in the formation of both. Earlier, Posner and Warren (1971) were concerned with how automatic structures (semantic memory) are derivable from traces (episodic experience) but they too dropped the question. Similarly, Kintsch asked how does "general knowledge (semantic memory) develop on the basis of particular experiences (episodic memory)" although he notes "this question need not concern us here"

(Kintsch, 1974, p. 79). Kintsch was also sensitive to the fact that nonverbal representation of knowledge must exist for he states that:

> It is unlikely that all knowledge can be represented in the same way. Propositional knowledge, which will be our sole concern, is primarily verbal, though it is possilbe to represent nonverbal information by such means as well . . . . On the other hand, analog representation of knowledge may underlie sensorimotor memory. The decision to neglect nonpropositional knowledge here by no means implies a judgment that only verbal sources of knowledge are worth considering for the psychologist. It merely reflects the state of the art today (Kintsch, 1974, p. 15).

This recurrent problem has especial importance for the developmental psychologist who must ask: how does the memory system of the young child encode and reconcile nonverbal and verbal sources of knowledge? How does the latter emerge from the former? Nelson's (1977) attempts to deal with this issue are of great importance for developmental theory and the adult models themselves could be enriched by a consideration of the developmental issue.

C. Semantic memory models.

Semantic memory models are currently fashionable and controversial (Collins & Loftus, 1976). I do not wish to enter this arena but will consider the models as they relate to the problem of growth. An excellent discussion of growth and semantic models can be found in several recent papers of Bransford and his colleagues (Bransford & Franks, 1976; Bransford & Nitsch, 1977; Bransford, Nitsch & Franks, 1977), and therefore I will only touch on the main points.

The main controversy engrossing semantic memory modelers concerns the nature of the organization in LTM, whether this is characterized as sets of features (Smith, Shoben & Rips, 1974), or networks of relationships (Collins & Loftus, 1976). The main game played by the participants is some variant of a verification task. Subjects are required to verify that a canary has skin, or is yellow. The latter they do more quickly--why? Whatever theory is espoused, a basic tenant is that the ease of verification can be accounted for by making assumptions concerning the preexisting structure of already acquired information.

> Theories of semantic memory therefore attempt to account for knowing solely on the basis of the structure of already acquired information. So-called "process" models of semantic memory are involved with elucidating how one uses already stored information to retrieve facts, make comparisons, etc. However these notions of "process" are not equivalent to the processes involved in the development of knowing. From the present perspective, the important processes involve knowing how to do something to go beyond what one knows right now (Bransford, Nitsch & Franks, 1977, ms. p.).

The major developmental forays in this area have been studies showing that children have networks similar to adults (Nelson & Kosslyn, 1975) but again without consideration of how these structures arose or developed.

Although it would be simplistic to deny that an important aspect of understanding involves the relationship between what is now to be understood and what is already known, Bransford and his colleagues are certainly right in emphasizing that it is at least equally important to consider how novelty is comprehended. Novelty cannot simply be understood as a recombination of already available information and this is nowhere more apparent than when one considers the problem of development. Children are universal novices; they must cope with novelty constantly. Semantic memory models cannot help us answer the problem of growth for they have not been primarily concerned with the issue of how one becomes a network, or feature repository, or how there develops a structure through which spreading activation can activate. This problem is isomorphic which the previously-mentioned question of how an abstract decontextualized system of knowledge evolves from the personal episodic experience of the child (Nelson, 1977; Nelson & Brown, 1978). The virtual equation of understanding with contacting previous knowledge must bring such models face to face with the problems of growth, novelty and preformism, problems which present difficulties for all psychological theories.

D. Schema theories of knowing.

Schema theories of human thought have been popular at least since Kant's (1787) Critique of Pure Reason; they have never been totally in abeyance although in the heyday of radical behaviorism they lurked predominantly under the cover of the "soft" areas of developmental (Piaget, 1928) and social (Allport & Postman, 1945; Bartlett, 1932) psychology.

It is probably true that some version of a schema theory is the dominant metaphor of current cognitive psychologists; at least it is a very healthy contender for that position, vying only with the competing information-processing computer metaphor. Computer metaphors themselves have begun to incorporate schema-like entities into their conceptualization. Minsky's (1975) frame notion, which has been favored by workers in the Artificial Intelligence field (Charniak, 1975; Winograd, 1975), and Schank's scripts and plans are basically schemata notions (Schank & Abelson, 1975). The LNR group has not been entirely uninfluenced by AI and they have also developed theories of schemata-driven cognition (Bobrow & Norman, 1975; Norman, 1975; Rumelhart & Ortony, 1977).

The defining features of schema theories are somewhat difficult to specify. The use of the term schema is widespread, vague and not always overladen with meaning. One of my favorite games is to remove the work schema from a paper written in schematese and look for changes in meaning. Take, for example, the sentence "preexisting knowledge schemata function to orient people to interpret a message in a certain way." Where is the loss of clarity in removing the word schemata. It is somewhat surprising to find that there rarely is a loss of meaning following such ablation tactics. The above sentence was one of my own, by the way, and I had already been through the paper eradicating superfluous schemata. To be fair, many of the more recent theories are far more precise in their use of the term (Rumelhart & Ortony, 1977), but there is still an abundance of needless schematese in contemporary cognitive psychology.

The major scaffolding of schema theories seems to be some version of the Piagetian assimilation and accommodation interaction, or the reflection, refraction transactions of Soviet dialectic theories (Wozniak, 1975). Assimilation is the function by which the events of the world are incorporated into preexisting knowledge structures while accommodation is the process by which the existing knowledge structures are modified in accordance with novel events. By the reciprocal influence of input on preexisting concepts and extant knowledge on input the thinker comes to know his world. There

are nontrivial problems associated with both terms. Recent theorists have taken divergent opinions on the issue, ranging from those who have few problems with assimilation but question how accommodation occurs (Anderson, 1977), those who accept accommodation but express concerns with assimilition (Neisser, 1976a), and those who appear to be disconcerted by both (Turvey, 1977). One cannot legitimately consider assimilation without accommodation or vice versa, as they are twin mechanisms in a dynamic transaction. But I will try to give the flavor of objections to both processes, as if they could be separated. In keeping with the focus of this chapter I will concentrate only on issues of critical interest to the basic developmental questions: growth and change.

A major criticism of schema theories in adult cognition is that they are basically assimilation models. Mechanisms which permit acquisition and articulation of schemata are not specified in sufficient detail to afford an adequate developmental perspective. How are existing conceptions modified in the face of inconsistent input? How do such theories deal with novelty? To say that "learning may be dealt with by supposing that when a radically new input is encountered a [new schema]without variables is constructed" (Rumelhart & Ortony, 1977, ms. p. 42), does not tell us either how we know it is a new input or how we construct a new schema. Similarly it is undoubtedly true that much schema growth can be accounted for by the twin processes of schema generalization and schema specification (Rumelhart & Ortony, 1977) but the theory is quite vague concerning the mechanisms and contexts which would permit such development.

The problem of growth is not only one of gradual extension and refinement of schemata but an adequate theory must be able to account for major changes in perspective (Anderson, 1977) or paradigmatic shifts of theory or world view (Kuhn, 1970). It must also deal with emotionally-based resistance to such major cognitive reorganization for it is true that inconsistencies and counterexamples are often assimilated into schemata to which a person is heavily committed, as Abelson's (1973) Cold Warrior example can illustrate. Accommodation is not the necessary result of inconsistent input. What

then would constitute necessary or sufficient conditions for a schema shift, or major accommodation, to occur? How does our preexisting knowledge change as a function of experience?--by gradual extension--by dynamic shifts in perspectives? (for a detailed discussion of this point see Anderson, 1977).

There are those for whom the problems of accommodation are relatively trivial for one must first account for assimilation. Gibsonian-attuned theorists find the latter to be the more problematic concept. Assimilation presupposes at least two interrelated assumptions that render the concept implausible for Gibsonians and embarrassing for schema theorists whose consciousness has been raised by this school (Neisser, 1976a). First, one can know only by reference to prior knowledge. Closely linked to this problem is the age-old one of preformism, or radical nativism, i.e., the organism must come prewired with a set of schemata; some knowledge about the world must be present from the very beginning.

The problem of preformism has been dealt with in depth by Shaw & Bransford (1977). No one really questions that phylogenetic attunement of some kind must preset an organsim to interact with his environment. Radical empiricism is no longer a viable tenant, for most contemporary theories accept some form of genetic attunement, some primitive universals, even though there is considerable discussion concerning what these might be.

The notion that assimilation involves epistemic mediation of some form is also a theoretically controversial one (Turvey, 1977). Gibsonians, as direct though critical realists, believe that everything we can perceive we perceive directly and there is no problem for such theories of input change or internal representation. Schema theorists on the other hand do invoke some epistemic mediation. Truly constructive theories are awkwardly autistic; if we truly construct our world, and we all construct it on the basis of our unique configuration of individual experience, it would be difficult to account for how accurately we perceive our world and how constant is the pattern of major ontogenetic change. Neisser (1976a) reaches a form of compromise in

that he assumes that perceiving does not change the world, it changes the perceiver, so that information in the world is only significant, indeed can only be picked up, if there is "a developmental format ready to accept it." For a full discussion of these differences the reader is referred to Neisser (1976a), Turvey and Shaw (this volume), Bransford, Franks, Morris, and Stein (this volume), and Shaw & Bransford (1977).

Thus a major problem with assimilation theories is the now familiar arguement that it is only possible to understand current input by reference to preexisting structures. This is as problematic for schema theories as for any other. And it is exacerbated by the tendency of some schema theorists to maintain the terminology of a memory metaphor by referring to schemata as if they were knowledge structures stored in the head. Schemata have slots into which things fit; frames often read very much like static places to put things in. But if this is so then one could only know by rifling through available schemata until one finds a suitable fit; or one could invoke a notion of content-addressable schemata!! This is one of the common pitfalls that schema theories wish to avoid. Experience does not result in the formation of an inner replica of an event in the head, but it functions more by altering or tuning the organism in such a way that it will see all subsequently related events in a new light. Reconstituted schema theories (Neisser, 1976a) do go part of the way in avoiding the content-addressable problem by this notion of tuning which is the result of the dynamic, reciprocal relation between the current cognitive-perceptual situation and the significant information in the environment (Bransford et al., 1977). Schemata are not filed in a library system in the mind. As Neisser points out, "someone who has a currently inactive schema should not be thought of as an owner of a particular kind of mental property. He is just an organism with a particular potentiality. His inactive schema are not objects but aspects of the structure of his nervous system" (Neisser, 1976a, p. 62). Similarly, Bransford's notion of experience setting the stage (Bransford & Franks, 1976) for grasping the significance of an event is a tuning notion which has much

in common with the Gibsonian concepts of the mutual compatibility between the organism's effectivities (goal-directed functions which reflect its potential actions) and the environmental affordances (Turvey & Shaw, this volume). There are major differences, to be sure, between the Gibsonian ecological theories and even reconstituted schema theories (Neisser 1976a), and these differences center on the problem of epistemic mediation (Turvey, 1977). But there is a convergence on the important issue which remains the mutual compatitility of the organism and its naturally evolving environmental niche.

In summary, the fundamental problems facing schema theories are the same as those that must eventually be confronted by any adequate psychological model. They must be able to deal with such issues as: ----with what preexisting structures must the nascent organism come equipped; how do these structures undergo change with age and experience; how does the organism go beyond its current state of knowing; how are the perceptual and cognitive systems pre-attuned by experience; in short, how do we account for cognitive growth. One of the major influences of the ecological theories (Shaw & Bransford, 1977; Turvey, 1977) is that they force us to address just those issues even if they cannot yet resolve them.

E. Developmental Theories

In the last stop in this quick tour of theories of cognition and the concept of growth, I will now consider briefly developmental theories, lumped together into one uneasy category. It is a natural step to go from a consideration of schema theories to the developmental literature as most of the dominant theories of cognitive development are based on some schema-like construct. This is true of European (Binet & Henri, 1894; Piaget, 1971), Soviet (Reigel, 1975; Wozniak, 1975), and American (Werner, 1948) psychology, in some guise or another. It would, of course, be impossible to give even a thumbnail description of the viable developmental models, and in keeping with the main focus of this section of the paper, I will concentrate only on how developmental models cope with growth. One might imagine that a consideration of theories

specifically addressed to growing organisms might provide some answers not found in adult models. A concern with growth should be a defining feature of a theory of cognitive development. Unfortunately this is not so; developmental theories have also been adept at avoiding the basic issue of growth by describing what develops rather than concentrating on how growth occurs. Indeed, just as a major problem with adult models is that they are generally silent on the issue of how thinking systems grow or change, so too, a major objection to many developmental models is that at best they provide a description of the stages or states of development but they cannot account for the transformations that lead to growth (Nelson, 1977). There is considerable disagreement surrounding even such basic issues as whether cognitive growth is a continuous process that proceeds slowly and gradually or whether it consists of a set of abrupt stage-like leaps (Flavell, 1971; Toussaint, 1974).

To illustrate how developmental models have difficulty with the concept of growth, I will use a somewhat extreme example. At a recent conference concerned with intelligence, Klahr (1976) presented a simulation of children's performance on Piagetian conservation problems. But, in order to successfully model this development Klahr would need to build into his system some accommodation-like process. In short, to model growth one must understand it. Neisser, as the discussant of the paper, pointed out that this is exactly what systems like Klahr's cannot do, for we do not yet understand the processes of growth. According to Neisser, the system proposed by Klahr

> . . . does not undergo accommodation; it does not learn. Klahr agrees that the issue of self-modification is central to the conception of intelligence, but neither his own system nor any of those reviewed by him meet this issue successfully. For better or worse my (Neisser's) 1963 claim that Artificial Intelligence has not modeled cognitive development remains valid. There is a reason for this. The development of human intelligence occurs in a real environment with coherent properties of its own. Many of these properties vary greatly from one situation to another; others remain invariant at a deeper level. As long as programs do not represent this environment systematically, in at least some of its complexity, they cannot represent cognitive growth either. (Neisser, 1976b, pp. 143-144).

Thus for Neisser, as well as for ecological theorists (Shaw & Bransford, 1977; Turvey & Shaw, this volume) the minimum unit of analysis must be the activity of

the organism in its natural environmental niche.

It is perhaps not too surprising that Klahr could not successfully capture the essence of accommodation in a computer simulation. But how successful in this regard, has been the pivotal developmental model, Piagetian theory. I have a sneaking suspicion that Piaget's theory is a gigantic projective test and it is possible to find there what one is looking for, surely a confirmation of Piaget's basic tenet. What follows is my interpretation of the essence of the theory. Piaget's theory rests on his changing notion of equilibration which is seen by some to be a homeostatic mechanism (Riegel, 1975). The organism is constantly seeking balance and stability. Every interaction with the environment precipitates a compensating equilibration activity consisting of both an assimilative and accommodative function. The end state of these reciprocal forces is balance. A problem here is that such a homeostatic notion would serve to maintain a child at a given level of development and one major issue has been how Piaget extracts himself from the dilemma of providing a basically homeostatic model to account for growth.

Piaget is not insensitive to this issue as some of his critics would have us believe (Riegel, 1974) and in his more recent writings he has introduced the homeorhetic (Pufall, 1977) processes of physical and reflective abstraction (Piaget, 1970, 1971). These are not easy concepts to come to grips with and luckily, for my purposes here, it is sufficient to point out that the major questions that Piaget is attempting to answer in his more recent work focus on the problem of growth. Indeed, Riegel (1974) has characterized Piaget's own development as one of three stages, the functional, the structural and now the transformational periods.

Thus, it would seem that even developmental theories have not yet arrived at a satisfactory conception of change and growth; as with adult theories the tendency is to fall back on an accumulation notion sometimes accompanied by reference to some unspecified qualitative reorganization at some unspecified critical stages. In defense of such theories, however, it should be said that they do address the issue; it is a

constant concern; it is the focal point where theoretical controversy centers. For example, the stage vs. continuous growth controversy (Flavell, 1971), which dominated the 1960s, centered on the problem of growth. In the 1970s, another theoretical controversy has arisen, although not everyone would believe it to be a controversy (Youniss, 1974), between Piagetian "structuralism" and Soviet dialectism as espoused by its American adherents (Riegel, 1975; Wozniak, 1975). This controversy was nicely illustrated by the football analogy introduced by Gardner (1973) and extended by Riegel (1974). In order to illustrate the methods of structural analysis used by Levi-Strauss to examine rituals and orgies of primative societies, Gardner subjected American football to a similar analysis. There is structure in the field, the rules of the game, and the strategies of performance. The action is characterized by a sequence of sudden quick actions each leading to a new structural state where the action appears to be temporarily frozen. Riegel believes this analogy is suitable for capturing the essence of a structural theory of growth like Piaget's early conceptions. By contrast, Riegel believes that dialectic theories, such as his own, can best be characterized by analogy to soccer, a game of ceaseless action which depends on continuous interactions between the individual members and the transaction between the members of opposing teams. Soccer, like dialectic theory, is a game of continuous motion; football, like structural theory, is one of sudden activity producing stable states. The analogy has flaws certainly, but it does illustrate that one of the current controversies in developmental theory, dialectism vs. Piagetian structuralism, is rooted in the notions of growth and change. Whether or not these theoretical metaphors ever lead to a concrete increase in our understanding of human growth, they at least sensitize us to a major problem for psychological theory.

Although space limitations must restrict my treatment of most aspects of the dialectic approach to human growth, I would like to add one point. Another criticism leveled against Piagetian theory by the dialectic school is that it concentrates on biological maturation and individual interactions with objects in the world; the

impression is that these forces play the primary role in development. By contrast, Riegel (1975) and his adherents stress the Soviet position that development is largely the result of socio-historical influences. I believe the difference is only one of emphasis and the value of both theories is the concentration on the individual, environment, and the mutual compatibility between the two. Together with many recent calls for an "ecological psychology" (Brown, 1977, 1978a; Brown & DeLoache, 1978; Bruner, 1972; Cole & Scribner, 1977; Neisser, 1976a, 1976b; Shaw & Bransford, 1977), the two major global developmental theories lay stress on the essential importance of considering ontogenetic and phylogenetic adaptation, as adaptation to dynamic natural contexts. Human thought is naturally evolving and although this undoubtedly complicates the issue, psychologists eventually must consider adaptation in reference to the particular socio-historical context in which the organism has evolved and must survive.

I would like to end this section with another quote from Neisser. "No theory that fails to acknowlegde the possibility of development can be taken seriously as an account of human cognition" (Neisser, 1976a, p. 62). As yet, neither the major adult or developmental models can satisfactorily account for growth, other than by postulating a gradual accumulation of facts, accompanied by some unspecified qualitative reorganization and restructuring. We are, however, beginning to see frameworks in which to couch the question, particularly Bransford and Nitsch's (1977) abduction schema, Neisser's (1976a) updated schema theory, Piaget's (1971) inchoate notions of reflective abstraction and the ecological theories of Turvey & Shaw (this volume). The main point of this section was not, unfortunately, to provide new insights into the problem of growth, but to illustrate that attention to issues of growth and change should be an essential factor in the formation of our conceptions about human thought.

III. Levels of Processing and Developmental Psychology

To have progressed this far in the paper without mentioning levels of processing (LOP) models might seem somewhat perverse given the theme of the volume but the participants were encouraged to consider alternate viewpoints. In the preceding section I dealt mainly with reasons why developmental psychologists and those concerned with adult cognition do not generally cross-fertilize each other's theory construction. In this section I will emphasize why it is that LOP frameworks are the major exception to this rule. From their very inception the LOP frameworks have been adopted and incorporated into the developmental literature. Why should this be so? What distinguishes LOP models from other adult models so that they are particularly compatible with developmental approaches? They certainly do not deal satisfactorily with the issue of growth, relying as they do on the typical gradual incremental notion. They bypass the thorny problem of assimilation-accommodation with statements such as "highly familiar, meaningful stimuli are compatible by definition (emphasis mine) with existing cognitive structures" (Craik & Lockhart, 1972, p. 676). Although they helped us avoid some of the less fruitful blind alleys of the container metaphors (Brown & DeLoache, 1978) they still maintain much of the terminology of general memory metaphors (Bransford & Franks, 1976). Why then have LOP frameworks been so readily adopted by developmental theorists?

I have described the major impact of LOP frameworks in previous papers (Brown, 1974, 1975) and Naus and Halasz (this volume) also give an excellent in depth review of the literature; I do not want to reiterate much of this discussion. I will argue here that the compatibility between LOP approaches and developmental psychology is due to the fact that developmental models have always been predominantly LOP frameworks. Both emphasize three (not independent) main points: (a) the concept of voluntary versus involuntary memory, (b) the idea that it is the activity of the subject that determines what is remembered, and (c) headfitting (Brown, 1975; Jenkins, 1971, 1974), nicely captured in Jenkins' quote: "the head remembers what it does" or is capable of

doing. These three points are the major issues that guide empirical work in developmental psychology whether the orientation is European (Binet & Henri, 1894; Piaget, 1970), American (Brown, 1975), or Russian (Istomina, 1975; Vygotsky, 1962; Yendovitskaya, 1971).

A. Voluntary vs. Involuntary Memory

1. Voluntary & Deliberate learning. A primary distinction made by Soviet developmental psychologists is that between voluntary and involuntary memory. This is roughly equivalent to the LOP distinction between incidental and intentional learning. Voluntary or intentional learning refers to the standard situation in laboratory memory tests (and schools) where the subject is specifically requested to invoke all efforts to retain the material. Under such circumstances adults deploy a remarkable array of ingenious mnemonics even when faced with the most impoverished stimuli or artificial laboratory tasks (Reitman, 1970); indeed, it is extremely difficult to interfere with this ingenuity. There is however ample evidence that young children do not spontaneously employ a variety of strategic methods until the onset of the grade school years and they continue to refine and extend their repertoire as they mature. Along with the gradual emergence and refinement of specific memorial strategies, the child's knowledge and control of these processes also develop as he is faced increasingly with more demanding situations. He learns to evaluate realistically the task demands (Brown, 1978a, 1978b), his memory ability (Brown, Campione, & Murphy, 1977; Brown & Lawton, 1977; Flavell, Friedrichs, & Hoyt, 1970), and the interaction of his abilities and the task (Brown & Barclay, 1976). The development of knowledge about memory, metamemory (Brown, 1975, 1977, 1978a; Brown & DeLoache, 1978; Campione & Brown, 1977; Flavell & Wellman, 1977), has only recently received attention, however, such knowledge and beliefs concerning one's own memory processes must play a vital role in determining if strategies and plans will be adopted and if appropriate plans will be used. Without such introspective knowledge, it would be difficult, if not impossible, to select an appropriate strategy at the onset of a task and to change or

modify that strategy in the face of its success or failure.

To illustrate the development of knowledge and control of deliberate strategies for learning, I will briefly describe some ongoing research from my laboratory concerned with acquiring information from prose passages (Brown & Smiley, 1977a, 1977b). Our subject population has ranged from preschoolers as young as three years of age to college students, and the stories are adapted to suit the different age groups. We find two main consistencies across age: with or without conscious intent to do so, subjects extract the main theme of a story and ignore trivia. Even the youngest child's recall favors the essential action sequences of the story. In addition, children are misled in their comprehension of stories by the same snares that trap adults (Brown, Smiley, Day, Townsend & Lawton, 1977). Led to believe certain "facts" concerning a main character or the location of an action, facts which never appear in the original story, children disambiguate and elaborate in the same way as adults (Anderson & Reder, this volume). They false recognize theme congruent distractors in recognition tests, and introduce importations from their preexisting knowledge when recalling. Furthermore, they have difficulty distinguishing between their own elaborations and the actual story content.

There are some interesting developmental trends, however, which follow from the increasingly strategic nature of the older child's study habits. As children mature they become able to identify the essential organizing features and crucial elements of texts (Brown & Smiley, 1977a, 1977b). Thanks to this foreknowledge, they make better use of extended study time. If given an extra period for study, children from seventh grade up improve their recall considerably for important elements of text; recall of less important details does not improve. Children below seventh grade do not usually show such effective use of additional study time; their recall improves, if at all, evenly across all levels of importance. As a result, older students' recall protocols following study include all the essential elements and little trivia. Younger children's recall, though still favoring important elements, has many such elements missing.

The older students benefit from increased study time as a direct result of their strategic intervention which in turn rests on their ability to predict ahead of time what are important elements of the text. Younger students, not so prescient, cannot be expected to distribute extra time intelligently; they do not concentrate on only the important elements, since they do not know in advance what they are. To substantiate this hypothesis consider the overt study actions of the subjects, in particular, the physical records they provided, notes and underlining of texts. A certain proportion of children from fifth grade and up spontaneously underlined or took notes during study. At all ages, the physical records of spontaneous subjects favored the important elements; i.e., the notes or underlined sections concentrated on elements of the text previously rated as crucial to the theme.

Students induced to adopt one of these strategies did not show a similar sensitivity to importance; they took notes or underlined more randomly. Some of the very young children underlined almost all the text when told to underline! Although the efficiency of physical record keeping in induced subjects did improve with age, it never reached the standard set by spontaneous users of the strategy. Furthermore, the recall scores of spontaneous producers were much superior. Even the few fifth graders who spontaneously underlined showed an adult-like pattern and used extra study to differentially improve their recall of important elements. The relationship between spontaneous strategy use and effective recall was clear for all ages.

This brief summary of some ongoing research illustrates what I believe to be a repetitive pattern in cognitive development. What develops with age and experience is often increasing strategic control over an early emerging process. For example, even young children extract the essential gist of a story if they are not misled by red herrings, such as artificially increased salience of nonessential detail. With increasing experience with such tasks children acquire the learning process and gradually refine their control over these strategies. Using their knowledge about elements of texts, their knowledge concerning how to study, and the interface of these two factors,

older students can become much more efficient when processing information presented in texts. A similar developmental pattern can be found in many other deliberate (voluntary) learning situations (Brown, 1974, 1975).

2. Involuntary Memory or Incidental learning. Involuntary memory is roughly the equivalent of incidental learning in the LOP framework, and indeed both the Soviet and American schools distinguish between two main types of involuntary memory. The first is the product of a deliberate learning task, for the subject is involved in a learning problem, during which he is exposed to material which is irrelevant to the task as specified by the learning instructions. This is a Type II incidental learning situation according to Postman's (1964) nomenclature. Both American and Soviet (Smirnov & Zinchenko, 1969; Vygotsky, 1962; Zinchenko, 1962) developmental psychologists have found the same pattern in children. As they mature, they increasingly attend to informative and ignore irrelevant aspects of a learning situation.

The second type of incidental learning situation, the Type I task (Postman, 1964), has generated the most interest within the LOP models. Here the subject is exposed to the stimulus material but is given no explicit instructions to learn; he interacts with the material for purposes other than the intent to learn per se. Under these circumstances, adults (Craik & Lockhart, 1972), as well as children (Istomina, 1975; Murphy & Brown, 1975; Smirnov & Zinchenko, 1969), retain more information if the orienting instructions are sufficient to induce optimal processing. The paradigm is of particular interest to developmentalists because a specific developmental prediction can be made. As young children are not noted for the production of effective strategies in response to instructions to learn, children performing a favorable orienting task should do better than those under instructions to attempt deliberate learning with no mention of what strategy they might adopt. Again, both Soviet (Vygotsky, 1962; Zinchenko, 1962), and American (Murphy & Brown, 1975) developmental psychologists have confirmed this prediction. In Table 1 we present some representative data. Although the absolute level

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Insert Table 1 about here

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of recall varies, as do the experimental procedures, the same pattern is observed. Intentional learners do more poorly than those performing any of a variety of semantic orienting tasks. Indeed, they perform at approximately the same level as children performing formal orienting tasks such as identifying the color of objects or initial sounds of words.

We have further evidence that it is the deployment of task suitable strategies that induces effective learning. Thieman (1976), in an unpublished doctoral dissertation, divided his intentional learners (adults) into subgroups depending on the strategy they reported using. These data are shown in Table 2. When one considers the com-

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Insert Table 2 about here

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bined mean for all intentional learners they appear to be performing as well as in the most effective semantic orienting conditions, a typical finding in the literature. However, when one considers the intentional learners, as a function of the strategy they adopt, the more ingenious tend to perform better than subjects in the best semantic orienting conditions and the less ingenious tend to perform as poorly as on the worst semantic orienting task and, indeed, as poorly as in the formal orienting conditions. These data, taken together with the developmental literature, provide strong support for the hypothesis that intentional learning instructions are only effective to the degree that they induce task suitable strategies. Instructions to learn per se are irrelevant.

As a final example of the interesting interaction of age by voluntary-involuntary memory conditions, I have chosen one of the original studies conducted with the paradigm by Zinchenko in approximately 1940 (see Wertsch, 1977, for translation). This is a particularly interesting study, not only because its early emergence reinforces a cyclical notion of history, all the elements of our current incidental-intentional studies are there, but also because it provides some evidence of an interaction between

orienting activity and the nature of the material to be processed, a basic LOP notion. Adult and child subjects were given sets of four words, each consisting of a target item (e.g., house) and three associates called logical (e.g., building), concrete (e.g., window), or no meaningful connection (fish). These are the only examples given so it is difficult to specify what a logical or concrete connection is exactly. However, from the example it looks like they are dealing with taxonomic-superordinate versus thematic categories (Overcast, Murphy, Smiley, & Brown, 1975). For adult subjects there were three incidental orienting tasks: underline the word in each set with (a) a logical connection, (b) a concrete connection, and (c) with no meaningful connection to the target. The data for immediate (surprise) free recall are given in Table 3. There is an interaction between type of material and orienting activity. Logical connections are recalled better than concrete ones, which in turn are recalled better than the unrelated

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Insert Table 3 about here

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items. Variations in orienting instruction, however, modify this somewhat, for, subjects seeking concrete connections remember as many concrete words as logical ones. Note also that the subjects in the no-connection group dramatically improve their recall of no-connection words. The interaction of material with orienting instruction is an interesting one which is repeated in the data from further groups of adults who performed the same orienting task together with instructions to learn the specific words they underline. The degree of retention is a function of both the type of material and the orienting task of the subject.

The developmental data, also included in Table 3, are incomplete and a little confusing. The pattern for young school children is reasonably clear. Incidental orienting instructions, if anything, produce better recall than intentional learning situations, even when the same activity was engaged in by both groups. For older children, the pattern is more complex. In the incidental condition, the same pattern of results is

found (with lower overall recall scores), for both adults and children, an interaction of orienting activity and stimulus type. In the intentional condition, however, a different pattern emerged. Zinchenko describes these middle school children as just at the stage when they had gained considerable control of mnemonics of rote recall, which they applied diligently. But they had great difficulty initially remembering any of the unrelated words; as a result they devoted considerable extra effort in the intentional condition, when asked to remember the unrelated words. Subsequently, they dramatically improved recall of unrelated words at the expense of the logical and concrete connections. This is a complicated study and its results can only be explained by recourse to much post hoc speculation (a clean replication would be welcomed); however, it does show that the interaction between strategies and material is an interesting one.

B. Activity and the Goal of Actions

Activity, referred to variously as mental operations or mental activity, is a central issue for LOP frameworks. Craik and Tulving summarized the literature in 1975:

> All these studies conform to the new look in memory research in that the stress is on mental operations; items are remembered not as presented stimuli acting on the organism, but as components of mental activity. Subjects remember not what was out there but what they did during encoding (Craik & Tulving, 1975, p. 292).

In its first instantiation this "new" focus on activity involved a somewhat simplistic conception of good and bad operations that could be performed by the learner. For example, it was easy to infer from the original descriptions of orienting activities that semantic ones were good and formal ones were bad. There are at least two problems with the invited inference. First it suggests a neat dichotomy between the types of tasks, and second it ignores the necessary relationship between a processing activity and the goal at hand.

Consider first the dichotomy notion. Semantic orienting tasks were thought to be those that required the subject to consider the meaning of stimuli, while formal tasks did not require a consideration of meaning. While the division of orienting

tasks based on the presence or absence of a requirement to consider meaning has a good deal of intuitive appeal, this view is not without its difficulties. First is the problem of determining an appropriate point of division between semantic and nonsemantic tasks, for several of the tasks selected appear to fall into a virtual no man's land. One difficulty of categorizing some tasks is that they can be preformed in several ways; so, the tasks themselves are neither semantic nor nonsemantic, but the operations carried out to perform the tasks can be based on either type of strategy. For example, determining the part of speech of words may be performed either by paying attention to the morphology or phonology of the words or by considering their meanings. This is not to imply that the two levels of decision are mutually exclusive, but differences in emphasis may explain why Hyde and Jenkins (1973) consider this a nonsemantic task, whereas Eagle and Leiter (1964) and Mandler and Worden (1973) consider it a semantic task. In short, a more reasonable assessment of the type of operations that can be performed by the learner is that they form a continuum in terms of the degree of semantic analysis that must be undertaken (Thieman, 1976).

A further problem related to the classification of tasks or underlying processes as semantic or nonsemantic on the basis of recall performance is the often cited circular and post hoc nature of this reasoning. Roughly, the argument states that since semantic or deep processing results in efficient retention, then if an orienting task produces high retention in incidental learning, it must have entailed semantic processing. But how strongly should the argument aligning memory and meaningful analysis be made? The strongest position holds that semantic processing is both a necessary and sufficient condition for good memory. This view is expressed by Craik and Tulving (1975), who state "it seems clear that attention to the word's meaning is a necessary prerequisite of good retention" (p. 269), and that "it now becomes possible to entertain the hypothesis that optimal processing of individual words, qua individual words, is sufficient to support good recall" (p. 270). An equally extreme alternative position would be that semantic analysis is neither necessary nor sufficient for good memory,

but the efficiency of retention is attributable to some other factor, such as the development of effective retrieval cues, which may be semantically or non-semantically related to the presented material.

A compromise between the two positions seems to have been reached (Tulving, this volume), i.e., recall of a large number of unrelated items will be unsuccessful, regardless of whether the meaning of each item has been considered, unless there exists some systematic retrieval mechanisms for reinstating those items at recall. Experiments by Craik and Tulving (1975), Schulman (1975) and Moscovitch and Craik (1975) also provide strong evidence that under certain circumstances semantic analysis is insufficient to insure high recall unless the products of this semantic analysis form a "coherent, integrated unit" which can serve as an effective redintegrative cue at recall (Horowitz & Prytulak, 1969). The compatibility of encoding and retrieval environments has been discussed at length by other contributors to this volume (Jacoby & Craik, Tulving & Bransford, et al).

The controversy concerning encoding-retrieval compatibility was a reaction to the early attempts of LOP adherents to classify activity irrespective of the goal of that activity. Postman (1975) suggested that there is a significant distinction to be drawn between deep processing and optimal processing; but optimal can only be defined in the context of the particular goal of the processing. Optimal processing must be whatever is most effective in the total context of the subjects' goal-directed activity; for it is the purposive nature of activities that guides the selection of information (Cassirer, 1946). Seen in this light, it should not matter where on the formal-semantic dimension an encoding activity might fall, the crucial variable would be the compatibility of the activity with the task demands, task demands that include retrieval as well as acquisition restraints. Bransford and his collegues (Bransford et al this volume, Morris, Bransford & Franks, 1977) report an experiment in support of this position, for under certain conditions a typical formal task, rhyming, can be superior to a typical semantic task, fitting words into sentences. The trick was that

the "retention" test required the subjects to make use of rhyme relevant information. The main point is that it is only in the context of what the subject is doing that one can meaningfully speak of optimal activity. This statement is also a fair representation of one of the basic tenets of the Soviet theory of activity (Leont'ev, 1974; Wertsch, 1977; Zinchenko, 1962), that actions, operations, and activities are always purposive; they do not occur in a vacuum; they occur in the context of some meaningful goal.

One of the main difficulties of giving a quick sketch of the Soviet theory of activity is confusion concerning their nomenclature, and I am sure that real devotees will find much to quarrel with in my usage of terms. The Soviets make quite subtle distinctions between terms such as activities, actions, acts, operations, motives, means, and goals. For this reason it is often difficult to follow their discourse, and I suspect that the problem is exacerbated because the terms, so subtly defined, originally, are sometimes used interchangeably by translators. A detailed review of the theories can be found elsewhere (Meacham, 1977; Wertsch, 1977); here I will give my translation of the major positions, changing the terms when necessary to be consistent.

The most difficult term is that of activity itself. Activities are defined as molar processes by which we

> transform objects into subjective forms and make objective the more subjective aspects of personality (cf, assimilation and accomodation in Piaget's theory). Thus activities structure the relationship of the individual to his material and social world, and it is through his activities that the individual is able to understand or give meaning to his external world (Meacham, 1977, p. 7).

Thus the term activity is used to refer to the assimilation-accomodation interaction of man and his external world. But it is also used to refer to the current social pursuit the individual is engaged in. At each stage of development, a particular form of activity becomes dominant, that is it is the "leading" activity of that stage of ontogenesis. It is within the context of the leading activity that the major reorganizations of mental processes will occur. For example, it is within the context of

manipulating objects and developing means of direct emotional communication, the leading activities of infancy, that the very young child comes to know his world, and to structure that knowledge. Although the sequence of leading activities will be modified by the particular environment in which the individual must function, the "normal" progression described by the Soviets for modern development in schooled societies is manipulation of objects and direct emotional communication, followed by play, then school-related learning and interpersonal communication, and finally career-related learning activities (Elkonin, 1972; Kussman, 1976). For example, it is a typical Soviet-inspired statement that the leading activity of schools is the development of decontextualized skills of deliberate learning (Brown, 1978a).

Activities, whether leading or otherwise, serve to motivate certain specific actions (sometimes confusingly called acts), which are directed toward a conscious goal. A goal-directed action can be performed by means of various operations depending on the particular task demand. Even these operations might have subparts, sometimes called acts, associated with them. To interject some well-needed concrete examples, consider the case of a child, during a play activity of constructing a toy boat, going to get a list of items needed for that construction. The leading activity of early childhood is play. The specific goal-directed action the child is currently engaged in is building the boat. One operation he must perform in order to carry out this action is remembering the list of items he must fetch, and an act of remembering might be rehearsal. Note that the operation of remembering here is subordinated to the action of building a toy; it is not the goal in itself. In another context remembering could be the goal. For example, consider an older child in a school situation who is directed to learn a vocabulary list. Here the leading activity of middle childhood is school-related learning; the specific goal-directed action is rote remembering; an operation that might be used to accomplish this could be rehearsal. Note two things: rehearsal, for example, out of context, cannot be designated an act, an operation, or an action. It can only be defined in terms of its place within the total activity of

the child in context. Second, note that in both examples, remembering is more or less deliberate, but in the second it is the goal itself, while in the first it is subordinated to the goal of building a toy. This is an important distinction for the Soviets, for they believe that actions that are the goal of an activity are better remembered than those that merely help one realize a goal, a point I cannot elaborate here. Finally, it should be emphasized that the voluntary-involuntary distinction as well as the definition of an activity can only be made in the context of a purposive goal-directed pursuit.

Although the terminology of the Russian literature may be less than helpful, the basic philosophy is simple and entirely compatible with the position that the subjects' activities are optimal only in the sense that they are tailored to some goal in a purposive sequence. Activities are purposive, goal-directed, and occur in natural contexts. The theory has much in common with that of transfer appropriate processes developed by Bransford and his collegues (this volume).

Before leaving the Soviet theory of activity, there is one implication that has particular relevance for developmentalists but also might be informative for those who deal with adult subjects. The Soviet position that one cannot divorce an activity from its purpose and that activities take place in natural contexts is beginning to have an important influence on the way developmental psychologists conduct their investigations. Developmental psychology as an experimental science is a relatively new area of specialization in American psychology. Initial forays in this field were very much influenced by experimental psychology which until the 1960s meant animal experimentation. The early questions were borrowed from the animal literature, and children were set to solve such gripping problems as two-choice discrimination learning tasks and run for many trials until they reached criterion -- or refused to cooperate. The experimental situation was also adapted from animal laboratories; a large number of studies in the 1960s actually used a modified Wisconsin General Test Apparatus -- a sort of cage developed by Harlow for testing monkeys. That children were also enclosed in

boxes was presumably a safeguard to protect the purity of the experimental demands, for I assume children in the 1960s were not rabid and, therefore, the physical protection of the experimenter could not have been a prime motivation. To complete the child as animal metaphor, it was a typical practice to place stimuli over reward wells which were baited (with M&Ms, the developmentalist's lab chow). All social or verbal interactions with the child were minimized, and any suggestion of a purpose for the activity was reduced to the plea to the child to "come play my game."

Children were notoriously unreliable accomplices; the variability in their data suggested perversity rather than compliance. Even if they reached solution, they were too temperamental to maintain a criterion run. The language, the experimental setup and the task were all inspired by the animal metaphor. Children usually outperformed animals but they still performed abysmally, and the resultant view of the young child was negative; he was not a producer, not strategic, did not mediate, did not transfer rules, etc. (Brown & DeLoache, 1978).

With the wide dissemination of the Russian developmental literature, American psychologists have begun to consider children's competencies in more naturalistic situations. Observational and clinical methods are being combined with experimentation in an innovative way, and it is becoming commonplace for developmental psychologists to at least pay lip service to the need to evaluate a child's potential in a meaningful situation. Soviet psychologists have always conducted their developmental inquiries in this manner. For example, Istomina (1975), in a study conducted in the early 1940s, examined how children would go about remembering a five item list. Americans will tell you that under normal laboratory learning instructions one can expect about two items from cooperative three-year-olds. But one of the most interesting features of Istomina's experiment was a comparison between children's memory for lists of words in the relatively standard list-learning situation vs. their memory for comparable lists embedded in a meaningful (to the child) activity of buying items at a store. Istomina's reasoning for contrasting these two conditions was the standard Soviet contention that

"the development of retention and recall as internal, purposeful acts takes place initially as part of a broader, articulated, and meaningful activity (since it is only within the context of such activity that the specific acts of remembering and recall have any meaning for a child)" (p. 8-9). This hypothesis was confirmed as recall was clearly superior in the game situation, for younger children, recall was twice as good when buying items at a store than in a typical rote learning situation.

Istomina not only recorded the objective data produced in each condition, she also observed the activities of the children as they undertook the task, thus providing a rich clinical picture of the developing skills. To extract some examples: Three-year-old Valerik barely waited for the list of items to be read before rushing off to the store. The three-year-old's view of the game seems to be limited to assuming the role of going to the store and returning with items, but does not seem to include the notion of bringing back the specific items on the list. Four-year-old Igor listened attentively to the shopping list, and then tried to carry out his errand as quickly as possible. He even seemed to try to avoid distraction, refusing to stop and talk when on his way to the store. Very few four-year-olds showed more specific mnemonic behaviors, but between four and five a qualitative shift seemed to occur, and all the older subjects seemed to make active attempts to remember. Some five- and six-year-olds actively rehearsed; they were often observed moving their lips, repeating the words over to themselves as the experimenter read them and as they walked to the store.

Many of the older children seemed to be monitoring their own memory states and even checking themselves to determine how well they would remember. Some children were even seen testing themselves on the way to the store. Finally, the oldest children (six-seven years old) displayed quite sophisticated strategies of trying to form logical connections between the items on their lists, often rearranging the order of the words based on their meaning.

Istomina's (1975) work is fascinating not just for the information it provides about young children's memory processes, but also for the methodological point it emphasizes. The best situation in which to study very early memory development is in a

natural context in which the child is likely to understand the task and be motivated to perform it. The young child's performance on laboratory tasks is often markedly inferior to his performance in a game setting. Although this variable is crucially important when studying very young children, the same general point is applicable to other ages as well. Subjects of any age, even adults, are likely to perform better in a meaningful task in which they are actively engaged. Mental acts occur in living contexts, and, to reiterate a previous theme of this paper, the minimum unit of analysis must be the operations performed by an individual in context (Neisser, 1976a). This is an extremely important point for developmentalists who must consider intelligent behavior of children in terms of the naturally occuring contexts of early childhood (Brown, 1975, 1978a) or divergent cultures (Brown, 1977, 1978a; Cole & Scribner, 1975). But the message might have some import for theories of adult cognition, particularly varieties such as LOP models, with their explicit concern with the influence of activities on levels of knowing.

C. Headfitting

The final point of compatibility between developmental psychology and LOP frameworks is a concern for headfitting (Brown, 1975; Jenkins, 1971, 1974). Again, I have dealt with this topic elsewhere (Brown, 1975), and Naus and Helasz (this volume) have a detailed overview of the problem. Here I will restrict myself to three points: headfitting as a source of error variance; headfitting for instructional purposes; and headfitting and the problem of meaning.

First, what do I mean by headfitting? The basic premise is that there is an intimate relation between what is known and what can be known, and because we must come to know more with increasing age and experience, there must be a close correspondence between what a child can understand at any point in his life and his concurrent cognitive status. The typical position of both adult and developmental constructivists is that meaning does not reside in the world, it is constructed from the interaction between the current state of knowledge and that which is to be known.

As we have seen, there are philosophical problems with this position (Sections II. D. and E.) which I will not reiterate here. But, the very concept of meaning for those of a constructivist persuasion is one of headfitting. LOP frameworks have always incorporated a headfitting notion, reflected in terms such as "compatibility (of material) with the analyzing structures." In more recent instantiations of the LOP approach (Lockhart, Craik, & Jacoby, 1975) the proponents become more explicitly embroiled in the problem, as they address the question of "automatic" encoding for material highly compatible with the preexisting contents of the head.

How have developmental psychologists been concerned with the headfitting issue? Experimental psychologists often operate as if they wished to control for it, e.g., they regard developmental variations in knowledge as a source of extraneous variability. For example, in standard memory tasks they attempt to insure that even their youngest subjects are familiar with the stimuli, at least to the level that they can name them. If a name is not readily given by a small participant, the experimenter generously provides one, and then operates as if stimulus familiarity were equated across ages (see Chi, 1978, for a full treatment of this problem). That familiarity may involve more than access, or even speed of access to the name code is rarely considered. Variations in performance across ages can now be attributed to factors other than variations in knowledge, e.g., capacity limitations or strategy deficits (Chi, 1976).

A more enlightened way that developmental psychologists have expressed concern with the headfitting problem has been in their treatment of instruction. If one wishes to instruct a child to perform in a way he previously could not, the most intelligent way to proceed is to find out where his head is at initially. Developmental psychologists interested in instruction have typically indulged in detailed task analyses that map the progression of the child as he moves toward adult-like understanding. Such task analyses provide detailed specifications of feasible rules for solution, and systematic error patterns are used to diagnose the child's pretraining competencies, areas of weakness, etc. so that instructional routines can be tailored to fit the diagnosee (Siegler, 1976).

It is widespread assumption of developmental psychologists of quite divergent theoretical viewpoints that the distance between the child's existing knowledge and the new information he must acquire is a critical determinant of how successful training will be (Brown, 1975; Inhelder, Sinclair, & Bovet, 1974; Piaget, 1971; Siegler, 1976). Near training, i.e., training aimed at just one level above a child's starting knowledge is far more successful than far training, aimed at least two levels beyond the child's understanding (Siegler, 1976). Thus, it is a critical concern for those involved in instruction to detail the stages through which the learner must pass. And the map between the child's current understanding and the instructional routine is a critical determinant of what instruction will be introduced -- a practical headfitting problem.

The third headfitting issue is the "task by h ad" interaction stressed by many developmental theorists. A task is easy or hard, material is comprehensible or not, to the extent that it maps onto the preexisting knowledge and preferences of the learners. Extreme versions of this approach suggest that if material is highly compatible, understanding will be "automatic" (Brown, 1975; Jenkins, 1974) and that both comprehension and memory are born of meaning (Piaget & Inhelder, 1973). One way that the developmental literature has been influenced by this position is that there has been a shift towards studying such phenomena as semantic integration, inferential reasoning, etc. in the context of meaningful materials such as prose passages. It is as if turning to prose is by itself a reflection of concern for meaning. As Jenkins (1974) pointed out in his seminal treatment of the psychologist definition of meaning, what one regards as meaningful is very much a matter of historical press. In their time those concerned with memory for words looked askance at retrogressive advocates of the nonsense syllable. Now it is trendy to berate those who look at words, or even sentences, for meaning is carried in larger chunks of texts. But if meaning is not in the material but in the compatibility of the subject's level of understanding and the nature of the material, then changing stimulus types does not help or hinder the basic question. Even for the learner attempting to acquire nonsense syllables the basic unit

of analysis is the relationship of his prior knowledge, his current activity, and the material. Both LOP frameworks and developmental theories that espouse a headfitting notion must somehow deal with the problem of meaning, where meaning is defined as one of task and subject compatibility.

The ultimate demonstration of the headfitting notion is one that should be readily found in the developmental literature. Ideally, little thinkers lacking some basic knowledge should be hindered in their comprehension of any information that presupposes the existence of that prior knowledge. While this is undoubtedly true, it has proved difficult to demonstrate the phenomenon neatly within well controlled experiments. The main thrust of the Piagetian work on the development of memory has been to demonstrate the close alliance of preexisting knowledge and memory (Piaget & Inhelder, 1973). These experiments have not been totally successful.

Another ploy is to show that experimentally induced preexisting knowledge determines what is understood. While this has been successfully demonstrated with both children (Brown, Smiley, Day, Townsend, & Lawton, 1977) and adults (Anderson & Pichert, 1977), no interesting developmental trends have been identified; even the younger children disambiguated vague or misleading sections of text in a manner congruent with their preexisting expectations. Indeed it is not necessary in the standard Bartlett prose recall situation to manipulate age as well as preexisting knowledge. Inducing adults to take different perspectives before reading a passage is an ideal way of demonstrating that comprehension is an interaction of expectations and actual textual materials (Anderson & Pichert, 1977; Bower, 1977). Thus, while we have ample anecdotal evidence that the younger reader's comprehension is effected by a limited knowledge base, e.g., reports that children read stories in terms of the concrete action sequences rather than the deeper allegorical meaning (Brown, 1978b), we do not have neat experimental evidence of the ideal type -- little heads leading to little understanding.

What we do have is the inverse of the ideal finding, and it is just as pertinent to my argument; indeed, it may be more so because it is so dramatic. In a recent

series of studies, Chi (1978) has been investigating the memory and metamemory performance of skilled chess players, an honorable psychological pursuit dating back at least to Binet (1894). Chi's twist is that in her sample of players knowledge is orthogonal to age. In general the children are the experts while the adults are the novices. It is the experts who outperform the novices both in terms of actual memory performance and in predicting in advance how well they will perform -- a nice example of the headfitting notion. It is not how old your head is but how much it has experienced in a particular cognitive domain.

IV. Summary

In view of the traditional separation of developmental theories from current adult models the widespread adoption of LOP frameworks is particularly noteworthy. I have suggested here that the essential compatibility of LOP models and developmental interests follows from a shared concern with three main issues, involuntary memory, activity and headfitting. Developmental data are often particularly apt demonstrations of the main tenets of the LOP frameworks and LOP models provide a language and a viewpoint through which the issues of interest for developmentalists can be reinterpreted.

Another theme of this chapter is that thinking systems are naturally evolving and theories of cognition must eventually consider how their model of man came about. The teleological position has been fruitful in guiding research but it is not surprising that any theory that can account for only a limited subset of adult behavior on a set of severely constrained tasks, may have difficulty dealing with the questions of growth and change. A consideration of the phylogenetic and ontogenetic force that shape the evolution of thought might lead to a richer understanding of how humans come to know the significant information of their environment.

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Footnotes

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Table 1

Proportion Correct Recall by Intentional and Incidental Learners: Preschool Children

Condition	Study 1[a]	Study 2[a]	Study 3[b]
Intentional Learning	.33	.22	.44
Semantic Orienting Tasks			
Categorize	.49	.41	.64
Buying Items at Store	.51	--	--
Nice-Nasty	--	.38	--
Formal Orienting Tasks			
Sound	.29	--	--
Color	.24	.18	--

[a]Adapted from Murphy & Brown (1975).

[b]Adapted from Zinchenko (1962).

Table 2

Mean Proportion Correct Recall of Intentional Learners as a Function of Strategy Adapted (from Thieman, 1976)

Group	Strategy	Experiments 1	2	3
Intentional Learners	(a) Stories, Sentences, or Scenes	.67	.59	.46
	(b) Interitem Associates or Categories	.36	.48	.45
	(c) Rote Rehearsal	.30	.37	.34
	Total	.44	.48	.42
Incidental Learners[1]	(a) Semantic Orientation	.33-.46	.38-.49	.44-.51
	(b) Formal Orientation	---	.30-.35	.31

[1]The incidental learners are included for comparative reasons. The orienting tasks varied widely across studies. Included here is the range between the least and most effective conditions.

Table 3

From P. I. Zinchenko, Involuntary Memory (1962)

College Student Data

Orienting Condition	Incidental			Intentional		
Instructions	Logical	Concrete	None	Logical	Concrete	None
Material						
Logical	7.0	5.9	5.2	7.1	5.2	4.8
Concrete	4.7	5.2	4.5	4.1	5.4	4.4
None	1.8	2.0	3.2	1.5	1.6	3.4
Old School Children						
Logical	5.7		4.1	8.3		2.8
Concrete	3.6		3.7	4.2		2.3
None	0.4		2.9	0.5		6.2
Young School Children						
Logical	5.4			4.0		
Concrete	2.6			2.4		
None	1.1			1.0		

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